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EFFECT OF INITIAL SOLIDS AND POLYMER DOSAGE ON THE EFFICIENCY OF IMPULSE DRYING SLUDGE

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ABSTRACT

The efficiency of impulse drying sludge is optimum at about 30% ingoing solids for a paper mill primary sludge. At lower solids, the sludge matrix is probably too closed for pressure dewatering to effectively occur. At higher levels, the surface water may be depleted to the point where sufficient steam is not generated. For a mixed sludge, impulse dewatering is relatively insensitive to polymer dosage, with low polymer levels providing the best results.

INTRODUCTION

In impulse drying, a hot roll contacts a wet sheet, converting some of the moisture at the interface to steam, the pressure of which forces out some of the water in the sheet in <u>liquid</u> form. Application of the technique to paper is complex, since heat transfer to the web must be tightly controlled in order to prevent sheet delamination (1-4). These considerations are absent for sludge, and laboratory-scale work has demonstrated that impulse drying belt-pressed industrial, municipal, and a mixture of municipal and industrial sludges removes up to an additional 20 percentage points of water (5-7), most of it as liquid. In subsequent pilot work, belt-pressed primary sludge from two paper mills was impulse-dried from 33 to 56% in one case, and from 32 to 46% in the other. Roll sticking or blinding of the belt was not observed at roll temperatures exceeding 200°C. In this paper, we report on the effect of the ingoing solids content on the efficiency of impulse drying, and provide preliminary data on the influence of polymer dosage on water removal.

EXPERIMENTAL

Laboratory measurements were conducted on a Materials and Testing Systems electrohydraulic press, illustrated in Figure 1. The heated upper platen impacts the sludge, which rests on a blotter, and the water expressed is removed at the grooved lower cold platen. A haversine pressure pulse is applied to simulate the pressure profile of the pilot machine. For studies on the effect of initial solids, primary sludge was obtained from Riverwood International's Macon, GA, mill. Sludge was obtained from the belt press at either 20 or 30% solids. A portion of the 30% sludge was sent to Ashbrook Corporation, where it was dewatered to 39% solids. For the polymer work, belt-pressed mixed sludge (70% primary and 30% secondary) was collected from Georgia-Pacific's Big Island, VA, mill. The sludge was conditioned with Praestol K133L (acrylamide copolymer), manufactured by Stockhausen Inc. Polymer dosage was varied from 4–10 mg/g of dry solids in increments of 2 mg/g. Sludge was collected for impulse drying as it emerged from the belt press. The Big Island facility conditions its sludge at 8 mg polymer per gram of dry solids. Sludge samples were impulse dried as collected from the belt press without adding additional polymer or any other conditioning chemicals. Characteristics of the belt-pressed sludge at different polymer dosages are presented in Table 1.

Table 1: Characterization of sludge from Big Island.

(mg polymer/g dry solids)	percent solids	average sheet thickness (mm.)	percent ash at 550°C
4	23.82	5.1	16.06
6	23.96	5.7	14.01
8[1]	24.84	6.9	14.24
10	24.67	6.4	12.14

[1]value used routinely by the mill

Table 2: Effect of initial solids on dewatering efficiency.[1]	
percent ingoing solids	increase in percent solids
20	17
30	23
39	6
[1]run at 700 ms., 1000 psi, and 350°C	

RESULTS

Effect of initial solids

Measurements were made at 350°C at a dwell time of 700 ms. For this sludge, the temperature is not critical beyond a threshold of about 200°C. Dewatering increases linearly with applied pressure, and the results reported here are for 1,000 psi. The application of pressure alone (without heat) removed about 2 percentage points of water; however, we have shown in pilot work that belt blinding occurs under these conditions (7). Little or no blinding results when heat and pressure are simultaneously applied.

The effect of ingoing solids on dewatering efficiency is illustrated in Table 2. Although the results are presented for a single pressure, the trends are maintained across the 400-2,000 psi range. Note that the efficiency peaks at about 30% solids. At lower solids, the sludge matrix is probably too closed for pressure dewatering to effectively occur. At the 39% level, the surface water may be depleted to the point where sufficient steam is not generated at the interface. In any case, the intermediate situation appears to offer the best combination of structure and surface moisture, and appreciable dewatering occurs. The practical aspect of this finding is that the sludge does not have to be extensively dewatered prior to the impulse; i.e., a relatively inexpensive belt press coupled to an impulse unit may offer the best option.

Effect of polymer dosage

Figures 2 and 3 show the effect of polymer dosage on impulse drying at 300 and 200°C, respectively. For both temperatures, dewatering was best at the lowest concentration of polymer used, 4 mg/g of dry solids; the outgoing solids were lowest at 8 mg/g. It is tempting to ascribe the differences in Figure 2 to variability, except that the same trends hold in Figure 3, and are consistent with the ingoing solids and sheet thickness data of Table 1. A thinner sheet is expected to dewater better under impulse conditions, albeit at a possible cost of throughput. Hence, we tentatively conclude that changes in polymer dosage induce real performance differences. Also, increased polymer dosage decreased the ash content of the belt-pressed sludge (Table 1), which could be due to an increase of biological flocs and cell debris in the sludge cake. This would reduce dewatering efficiency, since increasing the secondary content of sludge makes it more difficult to dewater. In any event, the best results are clearly obtained with minimal usage of sludge conditioning chemicals, which should substantially reduce dewatering costs. In future work, the effect of sheet thickness will be isolated from the influence of polymer.

Electric power costs of impulse drying

An illustration of the impulse dryer used in our pilot work (7) is provided in Figure 4. The power costs of heating the roll were determined with the following assumptions: top roll: 200°C; bottom roll: 30°C; ingoing sludge: 30% solids; outgoing sludge: 45% solids; speed: 10 ft/min.; sheet thickness: 0.5 inches; sludge density: 2.7 lb/ft^2; loss as steam: 5%; outgoing solids: 45%; outgoing sludge temperature: 45°C. Under these conditions, the amount of sludge processed is 1,590 lbs/hr of dry solids, and the total water removed is 1,777 lbs/hr. Heat is principally utilized to evaporate the small amount of water lost as steam. Other losses occur through heating the sludge and the expressed water, heat transferred to the belt, and radiative loss from the roll.

The radiative heat lost from the hot roll is given by

$$q_{rad} = \varepsilon\sigma A\left(T^4 - T^4_{ambient}\right)$$

where T is the roll temperature in °K; ε, the emissivity, equals 0.2; σ, the Stefan-Boltzmann constant, is 5.669×10^{-8} W/m^2 °K^4; and A is 2.336 m^2, from which q_{rad} = 1102 W = 4×10^6 J/hr (8). The heat required to warm the expressed water to 45°C is 48×10^6 J/hr. The heat lost through steam is 102 $\times10^6$ J/hr, and is 69x10^6 J/hr for heating the outgoing water and sludge. We assumed that dry primary sludge is mainly comprised of wood fiber whose specific heat was taken to be that of paper. Finally, the heat required to heat the stainless steel belt (790 kg/hr) is 6×10^6 J/hr, assuming a heat capacity of 480 J/kg.°K. The total heat requirement is, therefore, 2.2×10^9 J/hr or 61 kWH per dry ton.

Commercialization of the technology is being collaboratively pursued with Ashbrook Corporation, Houston, TX. Field trials for both paper mill and municipal applications are planned in 1998.

ACKNOWLEDGMENT

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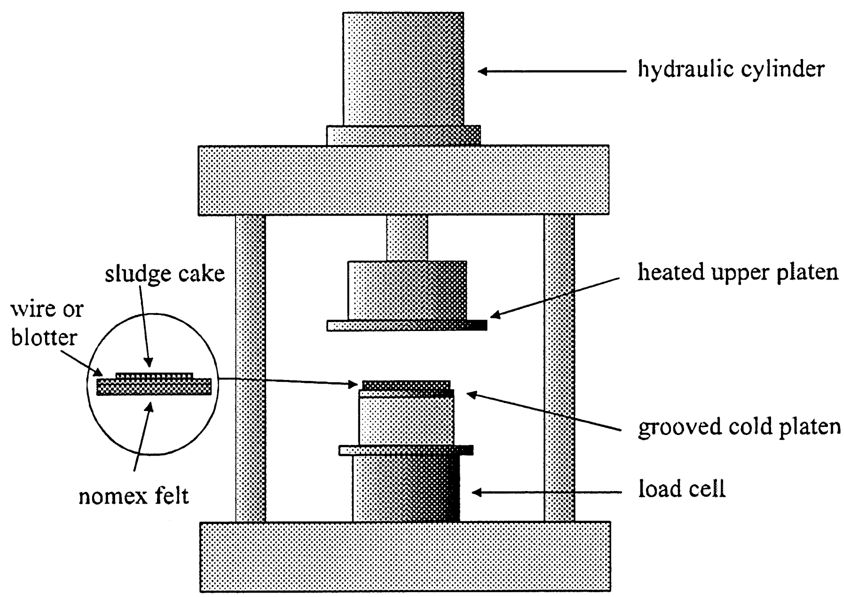

Figure 1: Schematic diagram of the MTS electrohydraulic press.

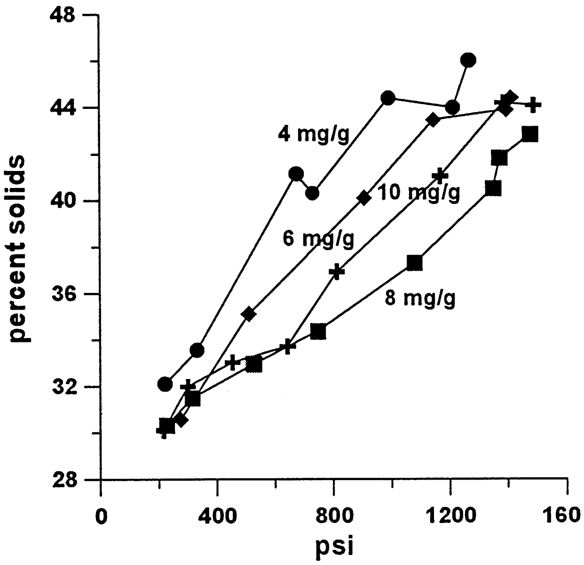

Figure 2: Effect of polymer dose on impulse drying at 300°C.
(• 4; ◆ 6; ■ 8; ✚ 10 mg/g dry solids)

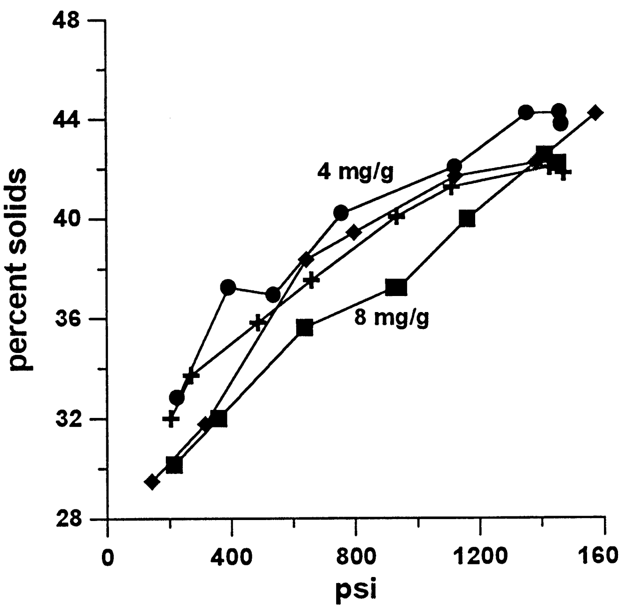

Figure 3: Effect of polymer dose on impulse drying at 200°C.
(• 4; ◆ 6; ■ 8; ✚ 10 mg/g dry solids)

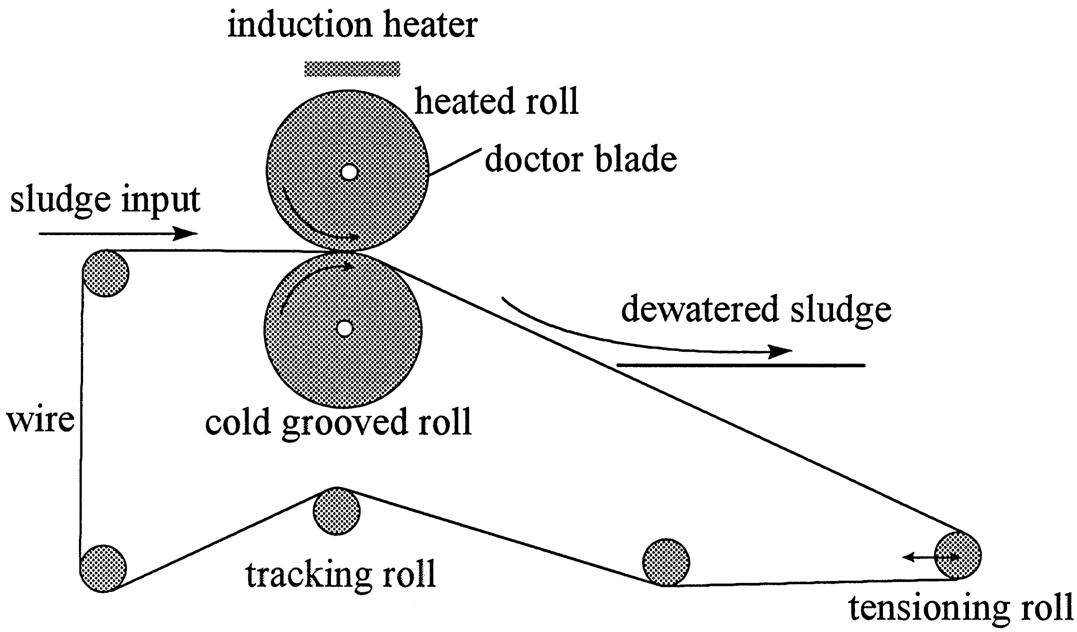

Figure 4: Side view schematic diagram of an impulse dryer.